STORMWATER TREATMENT AREA NO. 3 & 4

PLAN FORMULATION

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7. OPERATIONAL SIMULATION

7.1 INTRODUCTION

Long-term hydrologic simulations of the operation of STA-3/4 have been prepared. The primary purposes of those simulations are to:

- Assess the degree to which anticipated stage-durations and minimum and maximum depths in the interior of the treatment area can be expected to conform to the current basis for design. The current basis for design is established in the February 15, 1994 *Conceptual Design*, and is based on long-term data taken from WCA-2A. The development of a hydrologic regime paralleling that in WCA-2A is considered desirable inasmuch as the original design basis for estimating the performance of the stormwater treatment areas was developed from analysis of the performance of impacted zones in WCA-2A. That basis can be summarized as:
  - Maximum depth of 4.5 feet.
  - Minimum depth of 0.5 feet (adjusted from WCA-2A data, in which significant dryouts did occur, to prevent the undesirable release of stored phosphorus upon rewetting of dried-out areas).
  - Long-term mean depth of approximately two feet or less.
- Evaluate the impact of alternative seepage management schemes on the hydrologic performance of the treatment area, with specific emphasis on the manner in which different management schemes may influence the extent to which supplemental water may be needed to prevent dryout of the treatment area.
- Develop a complete water balance for STA-3/4 for subsequent use in projecting the probable performance of the treatment area in reducing total phosphorus in discharges to the Everglades Protection Area. Those treatment performance projections are included in Section 9 of this *Plan Formulation* document (PFD).
- Identify the degree to which the presence and operation of STA-3/4 may result in additional inflows (primarily due to induced seepage) to the Holey Land Wildlife Management Area. Section 10 of this PFD presents a comprehensive discussion of all anticipated impacts on the Holey Land, and presents recommendations for mitigation of those impacts.

A Visual Basic (VB) application has been developed to simulate the long-term performance of the STA 3/4 facilities. The purpose of this section is to describe raw data used in the analyses, the application's basic operating logic, specific input parameters used for each simulation, and the output generated for each simulation. In this section, the operational simulation is named “Period of Record” reflecting the nature of the analyses being based on 1965-95 information.

7.1.1 Scope of Work

The goal of the Period of Record (POR) analysis is to simulate water levels in STA-3/4 over a long period using historical hydrologic data furnished by the District. The analysis will address the frequency of dryout, the probable volume of supplemental water necessary to prevent dryout, lateral and deep seepage losses and recovered volumes, and the effects of various strategies to control seepage. Results obtained by this modeling effort will help refine the STA design and ultimately help gage the STA’s final nutrient removal performance and its ability to meet the interim discharge of 50 ppb.

Results from this work include a water budget from the STA including inflow/outflow, evapo-transpiration, rainfall, and seepage. Stage fluctuations within the STA are simulated using data for water years 1979 - 1988 and 1965 - 1995 provided by the District and flow routing algorithms developed specific to STA-3/4. Simulated Miami Canal and North New River Canal basin inflows to STA-3/4 were developed by the District through use of the South Florida Water Management Model (SFWMM). Additional discussion of that simulation and detailed information on those inflows is presented in Section 5 of this PFD. Seepage to or from the cells are simulated as a function of calculated differences in water surface elevation inside and outside the STA and algorithms based on the results of the geotechnical investigations and seepage analyses.

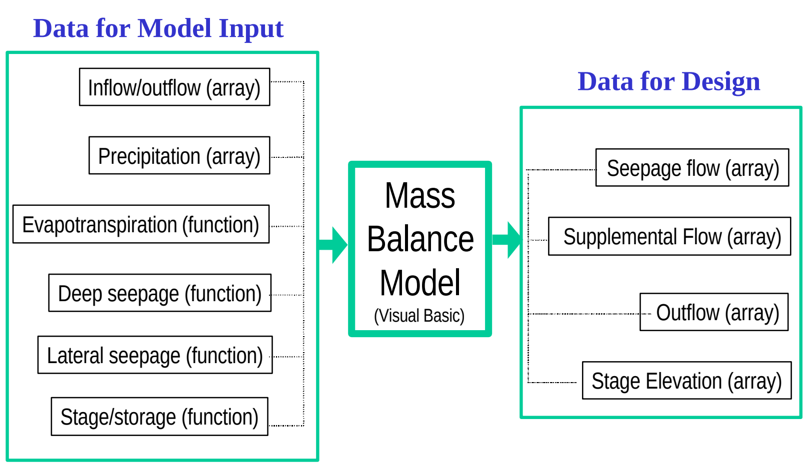
While seepage return provides a positive benefit in maintaining minimum water depths in the STAs, some have suggested that collection and treatment of seepage may diminish the overall nutrient removal performance. Providing optimal operation flexibility in seepage control will be one hydraulic aspect evaluated during the design of STA-3/4. This section describes dryout analyses using three seepage control scenarios described below. All scenarios include an estimate of groundwater losses to the Holey Land and other offsite lands, as well as an estimate of deep percolation losses:

1. All recoverable seepage losses are discharged offsite.
2. All recoverable seepage losses are returned to the STA.
3. Recoverable seepage returned depending on stages in the STA. If the STA stage drops below a specified minimum depth, seepage will be returned to the STA in an effort to minimize dryout or reduce the required volumes of supplemental water.

Previous studies conducted during the detailed design of other STAs indicated that rainfall induced runoff is typically not adequate to prevent dryout of the STAs during the dry season. In order to maintain a minimum stage within the STAs, supplemental water is required. *Each of the above scenarios will take into account the need to maintain at least 6-inches of water in the STA at all times and the amount of supplemental water supplies required to achieve this will be estimated.*

A mass balance model has been developed using Visual Basic (Appendix G). It is structured to read input arrays and execute functions in order to compute stage fluctuations over the Period of Record. A schematic diagram showing the relationships of basic data sources and the modeling tools is shown on Figure 7.1.

Figure 7.1 Model Input and Output Data



7.2 MODEL DESCRIPTION

7.2.1 Model Overview

STA 3/4 is bounded by Holey Land to the west, a supply canal and farmlands to the north, US 27 and the North New River Canal to the east, and the L-5 canal to the south. Its location is shown in Figure 7.2. The facility is being designed to treat flows from the Miami Canal and the North New River Canal. Flow from the Miami Canal will be conveyed to the STA 3/4 site via a 10-mile long supply canal. Flows from this supply canal will be introduced into Cells 2 and 3 in proportion to each cell's area. Cell 1 is being designed to collect and treat all flows from the New North River Canal. Generally speaking, flow enters the northern boundary of the STA and exits at the south end of the facility. Outflows will be collected in the L-5 canal.

The POR evaluations are designed to simulate seepage from both the supply canal and from the STA. Seepage from the supply canal may be lost to Holey Land (to the south) or to a seepage canal (to the north). Seepage from the STA is simulated using separate models for each of its three flow paths (Cells 1, 2, and 3). Internal levees within cells are ignored, and levees between cells are assumed to be impermeable such that any head differential between cells will not generate intercellular seepage. Seepage collection canals are included in the design along the northern boundary of the supply canal and along the eastern boundary of the STA. The location of the supply canals and flow control structures relevant to the STA are also shown in Figure 7.2. The logic used in the mass balance model and the functions used to estimate seepage losses are described in the following sections.

7.2.2 Model Logic

This section describes the general mechanics of the POR model, including how input and output is handled and what order the computations are processed. A schematic showing the sequence and general logic used by the POR model is presented in Figure 7.3.

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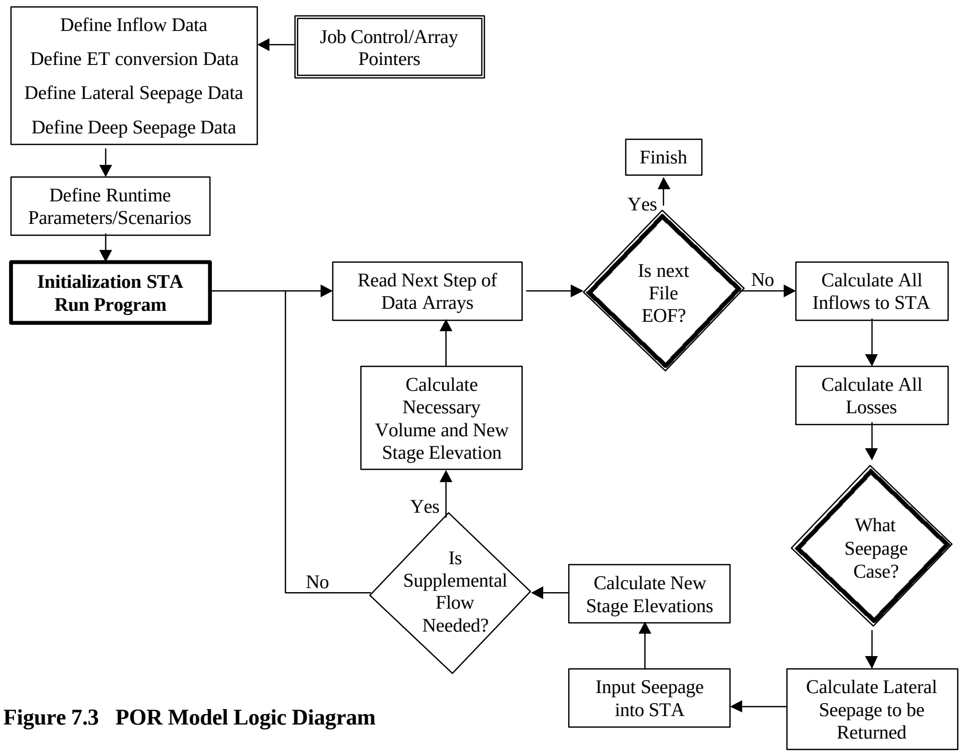


Figure 7.3 POR Model Logic Diagram

7.2.2.1 Input and Output Handling

The computations begin with a specified stage. This stage is either carried over from the calculations of the previous day's stage or is set at the beginning of the period of record to the cell's static depth. Based on this stage, the mass balance calculations are performed. Inputs are inflow, precipitation and returned seepage (if any). Outputs include outflow from the cell to the L-5 Canal, deep seepage, lateral seepage, and evapotranspiration. The resultant storage and stage for each cell are then calculated. If the depth within the cell drops below the minimum depth (6-inches) a supplemental flow is added to maintain the desired minimum depth.

The POR model does not account for changes in evapotranspiration, outflow, and/or seepage rates due to changes in stage elevation within any given day. More specifically, since ET is a function of stage elevation and stage elevation conversely changes with ET, the model does not take into consideration the difference, if any, of morning ET rates verses evening ET rates. The model is not sensitive to daily changes; no iterative solution is implemented.

Outputs from the mass balance calculations are processed to demonstrate each cell's performance characteristics and support the design process. Summaries from the POR simulations include tabulated annual flow volumes, maximum annual flow rates, and statistical graphs showing exceedance probabilities. The formats for the model output are similar to those reported in the *Final Design Report Stormwater Treatment Area No. 5 (STA-5)*, (Burns & McDonnell, 1997).

7.2.2.2 Model Verification

The POR model has been verified by comparing hand calculations to model output for several days chosen at random from the input data arrays. Results from this comparison indicated that the model is performing as designed. This detailed verification is included in Appendix H for review.

7.2.3 Data Arrays and Functions

The data arrays and functions inherent to the POR analyses are discussed below. These data arrays include “inflow” (stormwater run-off from the S2/S7 and S3/S8 basins), precipitation, and base evapotranspiration. Functions used in the POR calculations include stage-storage-discharge relationships for each cell (used to calculate “outflow”) and seepage rates.

This section of the report describes the raw data collected for the analyses and how the functions are used in the calculations. For use in the POR model much of this data has been incorporated into a Microsoft (MS) Access database. The MS Access database allows for more efficient data access and processing and is described in Section 7.2.4.

7.2.3.1 Inflow Array

The inflow array provided by the District in electronic form, represents stormwater run-off conveyed to the STA for treatment. Each data record has a date, its associated daily flow given in cubic feet per second (cfs). The time period of this data set is from 1965 – 1995.

Two flow arrays were provided by the District. The first is inflow from the New North River Canal (S2/S7 basins); these flows range from 0 to 1,860 cfs over the course of the 30-year period. The second array is the inflow from the Miami Canal (S3/S8 basins); flows from this canal range from 0 to 4,113 cfs.

An example of how the data is organized is shown below in Table 7.1. The POR model allows the user to choose which inflows to use for each simulation. The model also allows the user to specify multipliers or scalar relationships to modify the inflow characteristics.

Table 7.1
Example of Inflow Array

Date	NNR Canal (cfs)	Precipitation (inches)	Miami Canal (cfs)	Average ET (inches)
9/27/69	1659.00	0.00	214.00	0.12
9/28/69	1161.00	0.07	2098.00	0.11
9/29/69	544.00	0.18	697.00	0.12
9/30/69	443.00	0.12	118.00	0.15
10/1/69	54.00	0.00	604.00	0.15
10/2/69	1166.00	0.28	2904.00	0.14
10/3/69	790.00	0.00	3021.00	0.17
10/4/69	11.00	0.00	1344.00	0.20
10/5/69	0.00	0.02	1005.00	0.17

7.2.3.2 Precipitation Array

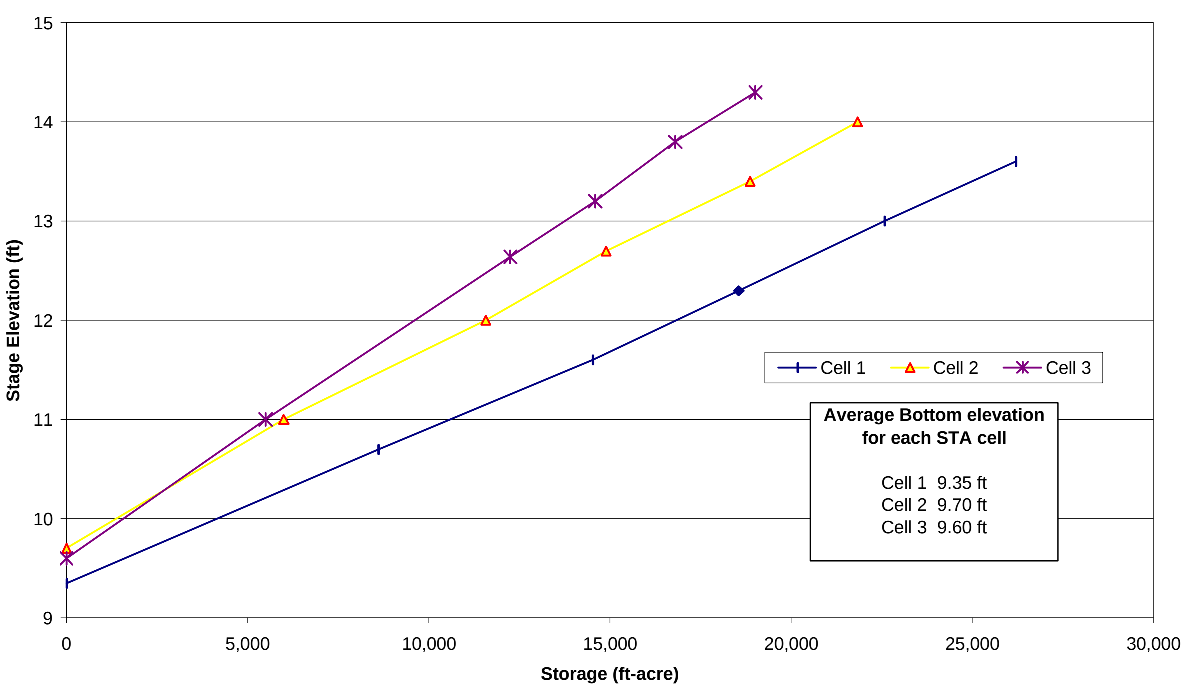
Rainfall quantities in South Florida are highly variable, both spatially and temporally. Daily precipitation depths were included in the District-furnished data, and represent the average of daily rainfall depths included in the SFWMM for those cells encompassing STA-3/4. The rainfall estimates provided by the District were used as the basis for the POR calculations. Each data record has a date and its associated rainfall depth. The available dates parallel the inflow data array.

Daily rainfall ranged 0 to 9.39 inches over the period of record. Annual precipitation totals ranged from 33 to 76 inches with a long-term average of 51 inches.

7.2.3.3 Stage/Storage/Discharge Functions

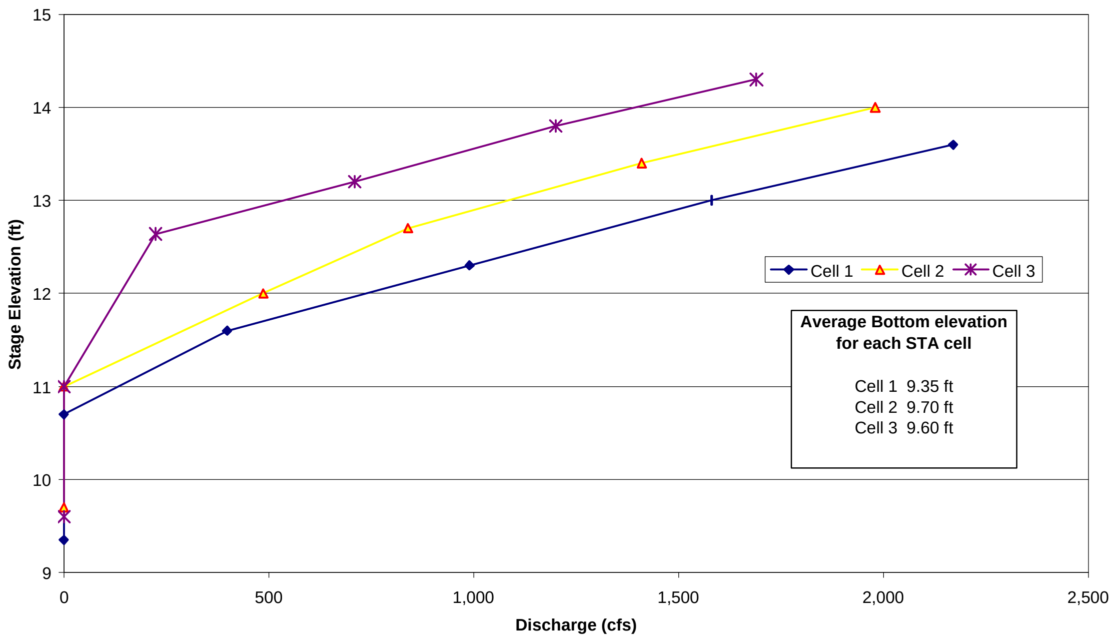
Stage/storage/discharge (SSD) relationships were developed for the recommended design configuration using output from the 2-dimensional (2-D) hydraulic models. The 2-D hydraulic simulations performed for each cell of the recommended design configuration are described in Section 6 of the PFD. For use in the POR simulations, output from these models were converted from ASCII format to MS Access format. From the MS Access database average flow depths and total storage volumes were calculated for each treatment cell (Cell 1, Cell 2, Cell 3) and the four flowrates that were simulated. The POR model uses both interpolation and extrapolation techniques to calculate stages, storage volumes, and discharge rates from these functions.
The stage-storage functions for each cell are shown in Figure 7.4. The stage-discharge functions are shown in Figure 7.5. The stages shown in the figures were calculated from the area-weighted average water surface elevations in each cell as computed from the 2-D model output. They are

Figure 7.4 Stage-Storage



also given as depths above the average ground surface elevation in each cell. The reference values used for the average ground surface elevation in each cell are also shown in the figures.

Figure 7.5 Stage-Discharge Relationship



7.2.3.4 Outflow Array

The POR model uses the SSD relationships to calculate outflow from the cells. The outflow rates represent the amount of water leaving each cell through outflow control structures (they do not include seepage loses). Outflow rates are calculated on a daily basis by interpolation or extrapolation of data defined in the SSD functions**.**

7.2.3.5 Evapotranspiration Array

Daily evapotranspiration (ET) depths were included in the District-furnished data, and represent the average of daily ET depths included in the SFWMM for those cells encompassing STA-3/4. The data array reflects ET rates for the anticipated land use and water depths in the STA. Each data record specifies a date and an associated base ET. The ET base estimates are developed using the Penman-Monteith equation referenced to a dense grass cover of 12 inches in height and a water depth of 2.0 feet.

Since actual ET is dependent on water depth and time of year, the District has provided algorithms based on the South Florida Water Management Model (SFWMM) that allow for runtime adjustments of the ET rate. While the algorithm is not overly complicated, the user must supply some additional input parameters. These include minimum ponding depth (OWPOND), depth from land surface to the bottom of the deep root zone (DDRZ), depth from land surface to the bottom of the shallow root zone (DSRZ), coefficients applied to ET for open water conditions (KMAX), and the depth from land surface to the water table (PND). The calibrated vegetation/crop coefficient (KVEG), which is a function of the time of year, has been incorporated into the Pdb. The program accesses this last table without any user direction.
The algorithm that calculates actual ET rates in its rudimentary form is

$$ET = KFACT * ETR$$

Where *ET* is the actual ET rate, *ETR* is the base ET rate (provided by the District), and *KFACT* is an adjustment factor calculated using Table 7.2.

Table 7.2
Variation of KFACT as a Function of Water Table Location

Depth from Land Surface to Water Level DWT: water table conditions, i.e. below ground PND: ponding conditions, i.e. above ground	**Adjustment Factor, KFACT**
$DWT \geq DDRZ$	0.0
$DSRZ < DWT < DDRZ$	$[(DDRZ-DWT) \div (DDRZ-DSRZ)] * KVEG$
$0 \leq DWT \leq DSRZ$	KVEG
$0 < PND \leq OWPOND$	$KVEG + (KMAX-KVEG)*PND \div OWPOND$
$PND > OWPOND$	KMAX

As noted previously, the water depth in the STA should not drop below 6”. Hence, only the last two rows of Table 7.2 are relevant to the analyses.

7.2.3.6 Lateral Seepage

Seepage rates for each boundary of each treatment cell are computed by the POR model on a daily basis. Two forms of seepage are addressed: lateral seepage and deep seepage. Lateral seepage is defined as seepage flowing between the treatment cells and a seepage collection canal, or between the seepage collection canal and the surrounding lands. Internal levees that separate cells are considered to have no head differential between adjacent cells and will be modeled as no-flow boundaries. As for seepage that makes its way into the collection channel, there is a possibility to recover a fraction of this volume by pumping the water back into the STA. It is assumed that deep seepage is unrecoverable.

Lateral seepage rates are described in Section 4 of the PFD (Burns and McDonnell, 1999). These rates are defined as a function of water surface elevations. Table 7.3 shows the recommended seepage loss rates for use in the design process. The specific values used in the POR simulations are highlighted.

Based on this table, lateral seepage rates are specified for each boundary that has potential seepage losses. Some boundaries may have two types of lateral seepage: seepage that is collected in seepage collection canals and seepage that is lost to net regional flow. Data specific to each cell are described in Section 7.3.

TABLE 7.3
Recommended Seepage Loss Rates for Use in Design
(All values in cubic feet per day/foot of length/foot of head)

Source	Range of Estimated Unit Losses								
	Seepage Canal			Holey Land			Net (Regional) Loss		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Supply Canal	N.A.	33.0	15.9	N.A.	34.7	7.1	N.A.	7.3	8.7
North Perimeter(4)	3.2	35.4	9.8	N.A.	N.A.	N.A.	1.7	7.2	11.4
East Perimeter, North(5)	7.4	44.7	14.6	N.A.	N.A.	N.A.	3.2	24.5	25.4
East Perimeter, South(5)	7.4	55.8	27.8	N.A.	N.A.	N.A.	3.2	28.7	11.3
West Perimeter	N.A.	N.A.	N.A.	12.2	54.8	22.1	N.A.	N.A.	N.A.
Cell 2A Outfall Canal(6)	N.A.	N.A.	N.A.	8.0	37.5	18.3	N.A.	N.A.	N.A.

1) From MODFLOW analysis; use for long-term hydrologic simulations
2) From SEEP2D Scenario A; use for maximum capacity of seepage collection canal and seepage return pumps.
3) From SEEP2D Scenario B; use seepage canal hydraulic profiles from this estimate for computing head differentials to be used in long-term hydrologic simulations.
4) Head differential between STA-3/4 interior and seepage collection canal stage.
5) MODFLOW results for East Perimeter based on overall seepage
6) Referred to as Cell 3 West in seepage modeling (“Toe of Boot”). Head differential between STA-3/4 interior and Holey Land stages.
7) Data highlighted indicates data used in the period of record analysis.

From Burns & McDonnell, 1999

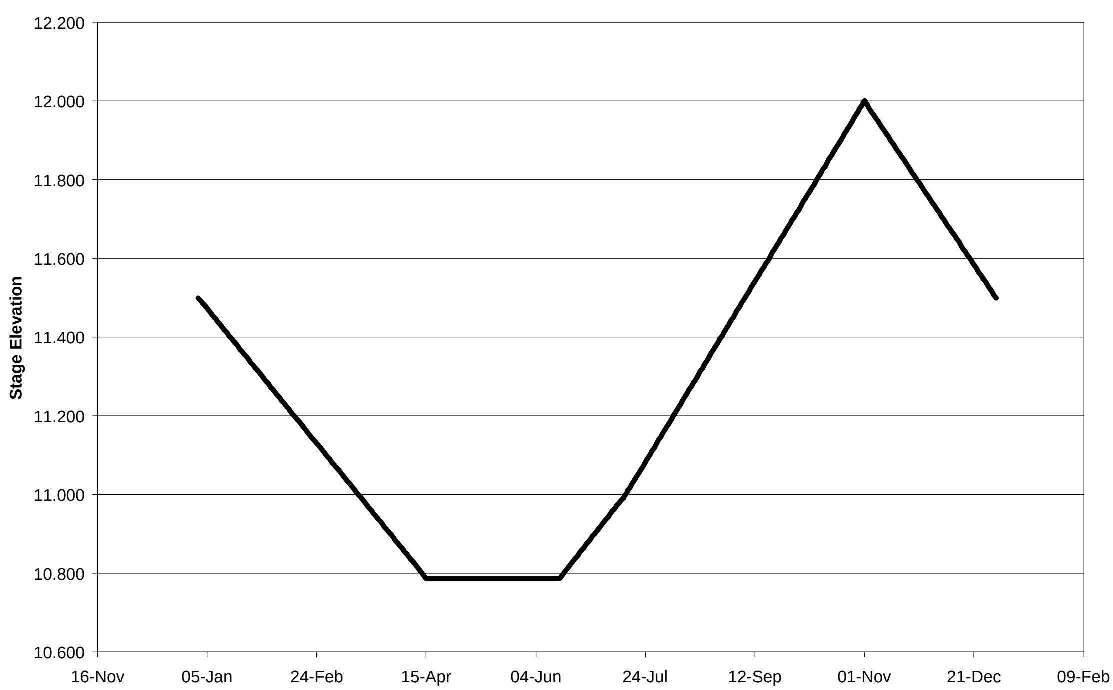
Head differentials used in the POR model are calculated during run time. While STA stage elevations fluctuate daily based on inflows and outflows, the receiving water’s stages may remain constant or fluctuate with a predefined schedule. For the Holey Land, the water depth is assumed to vary daily according the schedule seen in Figure 7.6. Additional discussion of that schedule is presented in Section 10 of this PFD. For other boundaries, it is assumed that the receiving water depth is constant. Specified depths are taken from the hydrogeologic seepage modeling of the STA as described in Section 4 of the PFD and shown here as Table 7.4. Where depths differ between seasons, the lower depth is used in order to simulate maximum seepage volumes.

TABLE 7.4
Stage Summary

Area	Simulated Water Level (ft NGVD)		
	Design	Wet Season	Dry Season
North Farm Lands	8.5	7.5	7.5
East Farm Lands	7.5	7.5	7.5
Seepage Collection Canals	7.5	7.5	7.5
North New River Canal	11.5	11.0	10.0
L-5 Canal	11.5	11.0	10.0
Water Conservation Area 2	11.0	11.0	11.0

From Burns & McDonnell, 1999

Figure 7.6 Holey Land Stage Schedule



7.2.3.7 Deep Seepage

Deep seepage is defined as seepage from the STA or seepage canals to groundwater. There is no possibility of recovering deep seepage.

The deep seepage rates specified in Section 4 of the PFD are described as lateral seepage lost to the groundwater at the levee boundaries. These rates are calculated by the POR model in a similar manner as lateral seepage flows.

7.2.3.8 Supplemental Flow

The POR model computes supplemental flow during run time. Supplemental flow is defined as additional flow necessary to prevent the cell's water surface depths from dropping below 6 inches. Output files of supplemental flow are generated over the period of record for each scenario.

7.2.4 Model Data Structure

Raw data collected for the POR analyses have been incorporated into a single Project Database (Pdb). This database has been created in MS Access. The individual components of the database are described below. The Pdb includes each of the data arrays and functions described in Section 7.2.2 and additional job control information required for the POR simulations. The structure of the Pdb is described below.

7.2.4.1 Data Structure Overview

The Project database (Pdb) constitutes the core components of the POR model inputs, and its structure is key to the success of each model run. It includes data tables and job control information combined in a single MS Access database file. Connection to the database from the POR model is imperative for its success. Correspondingly, the Pdb must be carefully structured according to the following guidelines.

Initially, there are <u>five tables necessary to run the model correctly</u>. The table names and their respective records are as follows:

> *Pdb Table 1 - Flow Descriptions* – This table holds the primary key information that describes the key of flows found in the flow table. There are three columns: "*ID"*, which are ET, PR, or IN for evapotranspiration, precipitation, or inflow respectively. The second

column "*Flow_Type*" contains the column heading for the flows in the Flows table. The last column "*Description*" provides space for an option narrative. For an example, see Table 7.5.

TABLE 7.5
An example of records in the Flow Description Table

ID	Flow_Type	Description
ET	Average_ET	Average Base Evapotranspiration
IN	Inflow_from_NNR_Canal	Inflow into STA from the NNR Area
IN	Inflow_from_Miami_Canal	Inflow into STA from the Miami Canal
IN	Total_Inflow_to_STA-3/4	Total inflow from NNR and Miami Canal
PR	Precipitation	Average Precipitation

Note that the Flow_Type names must match exactly the column names in the flow table.

Pdb Table 2 - Flows – This table contains the daily records for inflow, precipitation, and possibly any other input, such as inflow from the Miami Canal. However, the later does not need to be wrapped up into this table.

Table 7.6
Example Recordset for Flows Table

Date	Precipitation	Total_Inflow_to_STA-3/4	Average_ET
01/01/1965	0	55.85	0.1
01/02/1965	0	41.98	0.12
01/03/1965	0	0	0.14
01/04/1965	0	0.42	0.1
01/05/1965	0	0.2	0.11
01/06/1965	0	0.14	0.12
01/07/1965	0	0.24	0.11

Pdb Table 3 - Stage_Storage – The stage storage table simply lists the relationships in tabular form between the stage elevation (in feet), storage volume (in ft-acres) and discharge (cfs).

Table 7.7
Example of Stage_Storage Table

Cell Name	Stage	Storage	Discharge
Cell 1	9.35	0	0
Cell 1	10.7	8600	0
Cell 1	11.6	14523	398
Cell 1	12.3	18555	990
Cell 1	13	22569	1580
Cell 1	13.6	26188	2170
Cell 2	9.7	0	0
Cell 2	11	6000	0
Cell 2	12	11578	487
Cell 2	12.7	14893	840
Cell 2	13.4	18858	1410
Cell 2	14	21832	1980
Cell 3	9.6	0	0
Cell 3	11	5500	0
Cell 3	12.64	12252	224
Cell 3	13.2	14594	710
Cell 3	13.8	16801	1200
Cell 3	14.3	19015	1690

The computer program is able to differentiate between Cell 1 and Cell 2 as long as the Cell Name column is specified correctly.

Pdb Table 4 - KVEG – This table has information concerning the calibrated vegetation/crop coefficient. The table structure is shown in Table 7.8.

Table 7.8
Example of KVEG Table

Month	KVEG
1	0.852
2	0.802
3	0.850
4	0.875
5	0.883

Pdb Table 5 - Holey Land – this data table is simply a tabular representation of Figure 7.5. (Table 7.9).

Table 7.9
Example of Holey Land Table

Month	Day	Schedule
1	1	11.50
1	2	11.49
1	3	11.48
1	4	11.47
1	5	11.47
1	6	11.46
1	7	11.45
1	8	11.45
1	9	11.44

In addition to these five tables, the POR model will create a sixth table with the results for the simulation. This output data table will have the following record sets:

- Date,
- inflow in cfs
- computed outflow in cfs
- computed stage elevation in feet
- precipitation in inches
- computed evapotranspiration (actual) in inches

- supplemental flow in cfs
- Deep seepage flow in cfs
- Lateral seepage flow in cfs for each specified boundary.

7.3 MODEL RESULTS

7.3.1 Scenarios Evaluated

The POR model has been used to evaluate the long-term performance of the proposed STA facilities. The "recommended design configuration" described in Section 6 of the PFD has been used as the basis for these evaluations. Calculations have been performed for each of the STA's three flow paths, and for three seepage recovery scenarios. These scenarios are described below.

Scenario 1 – Recovered Seepage is Discharged Off-site

This scenario calculates the amount of seepage lost due to both lateral and vertical seepage flows. Seepage is not returned, regardless of whether or not it was collected in the seepage canals.

Scenario 2 – Recovered Seepage is Returned to the STA

This scenario calculates and reports all lateral and deep seepage volumes. It is assumed that all seepage collected in seepage canals is returned back to one or more of the STA cells for treatment. Seepage is returned regardless of depths in the treatment cells.

Scenario 3 – Recoverable Seepage is Returned during Dry Periods

For this scenario, all lateral and deep seepage is calculated and reported. Seepage collected in the seepage canals is returned to one or more of the STA cells when the depth drops below the static water depth. Deep seepage, as in the other two cases, is always lost.

7.3.2 Input Parameters

To simulate seepage losses and recovery, mass balance computations were performed in the sequence shown in Figure 7.7. This figure shows the relationships between the input data, the mass balance models, and each of the outflow arrays generated by the models. Seepage from the

STA was simulated using separate models for each of its flow paths (Cells 1, 2, and 3). Seepage from the supply canal was simulated in conjunction with the calculations for Cells 2 and 3 in proportion to each cell's area and inflow rates.

Input data used for each model are shown in Tables 7.10, 7.11, and 7.12. These tables show:

- basic data on each cell's area and control elevations,
- assumptions regarding inflow rates,
- stage, storage, and discharge relationships, and
- specific input data used to calculate seepage for each boundary of the models.

7.3.3 Annual Modeling Results

Tables 7.13 through 7.21 summarize the annual water balance data for each cell and each seepage recovery scenario. The tables summarize individual components of inflow, outflow, change in storage, and stage level data by year.

7.3.4 POR Modeling Results

Tables 7.22, 7.23, and 7.24 summarize the water balance data for the 31-year POR. Each table represents one of the seepage recovery scenarios. The water balance data is summarized for each cell and the total STA. The results for Scenario 1 indicate that an annual average of 18,293 acre-feet of supplemental water will be needed to meet the minimum depth requirements for the project. Results for Scenarios 2 and 3 indicate that an annual average of 5,853 and 6,411 acre-feet of supplemental flow are required. These volumes represent 32 to 35-percent of the volume required for Scenario 1.

Tables 7.22, 7.23, and 7.24 also show maximum daily flow rates and average daily flow rates by Cell for each individual component of Inflow/Outflow/Storage.

7.3.5 Stage Duration Results

A plot of stage depth (in feet) versus percent of time equaled or exceeded was created for each of the modeled cells and referred to as stage durations. Figure 7.8 presents the stage durations for

Cell 1 (Scenarios 1, 2, and 3). Figure 7.9 illustrates the stage durations for Cell 2 (Scenarios 1, 2, and 3). Figure 7.10 shows the stage durations for Cell 3 (Scenarios 1, 2, and 3). As expected the stage depth curve is lowest for Scenario 1 (where no seepage is returned) and highest for Scenario 2 (where all seepage is returned). The stage depth curve for Scenario 3 (some seepage is returned) lies between the stage depths curves for Scenario's 1 and 2. Depending on the cell and seepage control scenario selected, these graphs show that supplemental water may be required between 4 and 18-percent of the facility's operating history. These graphs can also be used to identify the average depth within each cell for the 31-year POR.

7.3.6 Discharge Duration Results

A plot of discharge to the L-5 canal (in cfs) versus percent of time equaled or exceeded for each scenario is presented in Figure 7.11. As expected the discharge is the lowest for Scenario 1 (where no seepage is returned) and highest for Scenario 2 (where all seepage is returned). The discharge duration curve for Scenario 3 (some seepage is returned) lies between the discharge duration curves for Scenario's 1 and 2.

7.4 EVALUATION

The results of the simulations for the three operational scenarios have been evaluated for:

- The extent to which projected stages conform to the basis for design.
- The influence of seepage management alternatives on the need for supplemental water to maintain not less than 6 inches of average depth in the treatment area.
- The relative influence of the seepage management alternatives on induced seepage to the Holey Land Wildlife Management Area.
- The impact of seepage management alternatives on total surface water discharges to the Everglades Protection Area.

7.4.1 Conformance to Desired Stages and Stage-Durations

Inspection of Figures 7.8, 7.9 and 7.10 indicates that the projected performance of STA-3/4 conforms closely to the basis of design for each of the seepage management alternatives. Of course, minimum depths in the cells are in each instance constrained to the desired 6 inches through the addition of supplemental water to prevent dryout. Maximum depths in Cells 1 and 2 fall below the 4.5-foot criterion. The maximum simulated depth in Cell 3 falls slightly above that criterion (overall, less than one percent of the time).

Long-term mean depths in Cell 1 fall generally between 1.5 and 1.7 feet for each of the scenarios considered (target of 2.0 feet or less). Long-term mean depths in Cell 2 fall generally between1.6 and 1.7 feet. Long-term mean depths in Cell 3 range from 2.0 to 2.3 feet, with the maximum depth resulting from the scenario in which all recoverable seepage losses are returned to the treatment area.

While all results are considered acceptable, it would appear desirable to lower projected stages in Cell 3 roughly 0.2 feet. As additional topographic data is made available during the detailed design phase, the potential for reducing the static water surface elevation in Cell 3 from 11.0 ft. NGVD to approximately 10.8 ft. NGVD should be considered and implemented if the mean ground surface elevation in the completed cell is 9.5 ft. NGVD or less. No change in the design of physical works would be necessary for that operational modification.

7.4.2 Demand for Supplemental Water

The estimated average annual demand for supplemental water under Scenario 2 (all recoverable seepage returned) and Scenario 3 (recoverable seepage returned only when the treatment cells fall below static water surface elevation) are 5,853 and 6,411 acre-feet per year, respectively, for the period 1965-1995. Some demand for supplemental water would result in roughly 2/3 of the 31 years simulated. Little difference is seen between those two scenarios, although the demand is slightly less for Scenario 2.

The estimated average annual demand for supplemental water under Scenario 1 (no return of recoverable seepage) is 18,293 acre-feet per year. Under this scenario, the demand for supplemental water markedly exceeds that for Scenarios 1 and 2. The results of the simulation confirm the need for inclusion of means to return recoverable seepage to the treatment area, purely with respect to additional demands for water placed on the regional system under Scenario 1.

It should be noted that previous SFWMM simulations conducted by the District suggested no need for supplemental water to prevent dryout in STA-3/4. The presence of STA-3/4 was, out of necessity, handled more simplistically in those analyses. The primary difference between those previous simulations and those reported herein is the increased level of detail and updated estimates of seepage presented herein. The previous District simulations simply assigned a uniform (unrecoverable) seepage loss of 0.3 meters per year to the footprint of STA-3/4. Total seepage losses estimated in this analysis average approximately 3.6 meters per year, with the extent of recovery dependent upon seepage management strategies. That total estimated seepage is roughly equivalent to previous estimates prepared by Brown & Caldwell for STA-2 (Detailed Design Report, Contract No. C-E201A, Final Amendment No. 1 dated August, 1996).

7.4.3 Induced Seepage to the Holey Land Wildlife Management Area

The estimated average annual seepage volume to the Holey Land over the period 1965-1995 is 14,654 acre-feet per year under Scenario 1; 19,624 acre-feet per year under Scenario 2; and 15,908 acre-feet per year under Scenario 3. The estimated maximum annual seepage volume to the Holey Land (occurring in 1970) is 35,275 acre-feet under Scenario 1; 39,128 acre-feet under Scenario 2; and 35,496 acre-feet per year under Scenario 3. It is concluded that there is no significant difference between Scenarios 1 and 3 with respect to the loss of water to the Holey Land; Scenario 2 would generally increase those losses (as compared to Scenarios 1 and 3) by roughly 4,000 acre-feet per year.

The maximum annual loss to the Holey Land of 39,128 acre-feet per year in 1970 under Scenario 2 is equivalent to a uniform discharge rate of 54 cfs, roughly 5 cfs greater than the maximum annual loss under Scenarios 1 and 3.

7.4.4 Total Surface Water Discharges to the Everglades Protection Area

Total estimated discharges from the STA-3/4 outflow control structures to the L-5 Borrow Canal average 470,118 acre-feet per year under Scenario 1; 544,108 acre-feet per year under Scenario 2; and 479,571 acre-feet per year under Scenario 3. Considering only that component of total outflow, it might be concluded that Scenario 2 would result in markedly increased discharges to the Everglades Protection Area than would Scenarios 1 and 3.

However, it must be recognized that recoverable seepage under Scenarios 1 and 3 would also be directly discharged, and should be added to the discharges from the outflow control structures to complete the accounting. Under Scenario 1, an average annual volume of recoverable seepage equal to 85,219 acre-feet per year would be directly discharged, part to the Miami Canal at Pumping Station G-372, and part directly to the STA-3/4 discharge canal (and L-5) at the south end of the east perimeter of the treatment area. As a result, the total surface water discharge under Scenario 1 is estimated at 555,337 acre-feet per year, roughly 2 percent more under than under Scenario 2. Total discharges under Scenario 3 will fall between those two values.

No significant advantage is identified for any seepage management alternative with respect to the total volume of surface waters discharged to the Everglades Protection Area.